湛庐文化

财富汇

圣塔菲研究所元老、复杂性科学奠基人
著名经济学家、首屈一指的技术思想家

布莱恩·阿瑟最新力作

技术的本质

技术是什么，它是如何进化的

[美] 布莱恩·阿瑟（W. Brian Arthur）◎著

曹东溟 王健◎译

The Nature of Technology

What It Is and How It Evolves

浙江人民出版社

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ZHEJIANG PEOPLE'S PUBLISHING HOUSE

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THE NATURE OF TECHNOLOGY

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目 录

THE NATURE OF TECHNOLOGY

第1章 问题

技术给我们带来了舒适的生活和无尽的财富，也成就了经济的繁荣。一句话，我们的世界因技术而改变。但是，技术的本质究竟是什么呢？它从何而来，又是如何进化的呢？

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第2章 组合与结构

新技术都是在现有技术的基础上发展起来的，现有技术又来源于先前的技术。将技术进行功能性分组，可以大大简化设计过程，这是技术“模块化”的首要原因。技术的“组合”和“递归”特征，将彻底改变我们对技术本质的认识。

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第3章 现象

无论是简单还是复杂的技术，都是在应用一种或几种现象之后乔装打扮出来的。技术就是那些被捕获并使用的现象，是对现象有目的的编程。我们一直以为技术是科学的应用，但实际上却是技术引领着科学的发展。

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[illegible]·[illegible]Gerrit Moll[illegible]Ørsted[illegible]11[illegible]

[illegible]

[illegible]

[illegible]
1750 —1875[illegible]

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[illegible]

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John G.Truxal [4]

19

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[illegible]“[illegible]”[illegible]

[illegible]X[illegible]DNA[illegible]DNA[illegible]X[illegible]

[illegible]·[illegible]Robert Millikan[illegible]1910[illegible]1911[illegible]

[illegible]

[illegible]5[illegible][5][illegible]

[illegible]technique[illegible]5[illegible]—— [illegible]

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[illegible]

[illegible]

[illegible]

[illegible]core structure[illegible][6]

[illegible]forms from[illegible];[illegible]knowings[illegible]

THE NATURE OF TECHNOLOGY [illegible]	[illegible]

[illegible]

[illegible]

[illegible]?[illegible]builds from[illegible]

[illegible]·[illegible]Joel Mokyr[illegible]“[illegible]400[illegible]”[7]

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[illegible]“[illegible]”[illegible]

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[1] [illegible]——[illegible]

THE NATURE OF TECHNOLOGY

第4章 域

为了共享现象族群和共同目标，或者为了分享同一个理论，个体技术就会聚集成群。这种集群就形成了“域”。工程设计是从选择某个域开始的，这个自动和下意识的选择过程叫作“域定”。设计工作就像是用某种语言所进行的写作或表达。

[illegible]“[illegible]”[illegible]

[illegible]2[illegible]“[illegible]”[illegible]

[illegible]building blocks[illegible]DNA[illegible]DNA[illegible]

[illegible]

[illegible][1]

[illegible]

[illegible]–[illegible]“[illegible]”[illegible]“[illegible]”[illegible]“[illegible]”[illegible]domaining[illegible]“[illegible]”[illegible]

[illegible]Linux[illegible]Windows[illegible]

[illegible]——[illegible]

THE NATURE OF TECHNOLOGY

[illegible]“[illegible]”[illegible]

[illegible]“[illegible]”[illegible]20[illegible]70[illegible]fly-by-wire[illegible]

[illegible][2][illegible]“[illegible]”[illegible]

[illegible]“[illegible]”（inherently unstable）[illegible]“[illegible]”[illegible]

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[illegible]20[illegible]30[illegible]15[illegible]20[illegible]

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[illegible]1821[illegible]·[illegible]Charles Babbage[illegible][3][illegible]·[illegible]John Herschel[illegible]“[illegible]”[illegible]19[illegible]20[illegible]

[illegible]·[illegible]Jules Verne[illegible][4][illegible]19[illegible]60[illegible]18[illegible]

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18 “clichés”

THE
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Henry James

[5]

Erwin Chargaff 1949 DNA

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[illegible][7][illegible]DNA[illegible]DNA[illegible]“[illegible]”[illegible][8][illegible]——[illegible]“[illegible]”[illegible]

[illegible][1][illegible]rules of thumb[illegible]“[illegible]0.2[illegible]0.3[illegible]”[illegible]Cordon Bleu[illegible][2][illegible]unspoken practices[illegible]practical knowing[illegible]

[illegible]“[illegible]”[illegible]knowingness[illegible]——[illegible]

[illegible]·[illegible]James Newcomb[illegible]“[illegible]

[illegible]”[9]

[illegible][10][illegible]“clichés”[illegible]

[illegible]“[illegible]”[illegible]

[illegible]“[illegible]”[illegible]

[illegible]·[illegible]Paul Klee[illegible]“[illegible]……[illegible]”[11][illegible]

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[illegible]·[illegible]Charles Townes[illegible]

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[illegible]·[illegible]Paul Goldberger[illegible]“[illegible]”[illegible][12][illegible]——[illegible]“[illegible]”[illegible]

[illegible]8[illegible]

[illegible]DNA[illegible]re-expressing[illegible]re-domaining[illegible]

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[1] [illegible]——[illegible]

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第5章 工程和对应的解决方案

几乎所有的设计都是某个已知技术的新版本，只有在必要的情况下，才需要一项全新的设计。工程师在寻找解决方案的过程中，把适宜的构件选择出来，让它们组合在一起工作。设计就是选择，组合只不过是工程的副产品。工程的解决方案，又成为发展新技术的新构件。

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[illegible]–[illegible]Atanasoff-Berry machine[illegible]Eckert and Mauchly’s ENIAC[illegible]EDVAC[illegible]parent domain[illegible]

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[illegible]·[illegible]“[illegible]”[illegible]

[illegible]“[illegible]”[illegible]“[illegible]”[illegible]“[illegible]”[illegible]

[illegible]forming[illegible]“[illegible]”[illegible]radical innovation[illegible]

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[illegible][1][illegible]“[illegible]construction[illegible]”[illegible]“[illegible]manufacture[illegible]”[illegible]“[illegible]”[illegible]“[illegible]”[illegible]

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[illegible]form[illegible]architected assemblies[illegible]

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[illegible]desiderata[illegible]20[illegible]60[illegible]747[illegible]·[illegible]Joseph Sutter[illegible][2][illegible]350[illegible]9~10[illegible]

[illegible]——[illegible]350[illegible]

[illegible]

[illegible][3][illegible]

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[illegible]1965[illegible]747[illegible]1:1[illegible]6:1[illegible]Pratt[illegible]Whitney[illegible]JT9D[illegible]8[illegible]77%[illegible]WD–40[illegible]

[illegible]“[illegible]”[illegible]“[illegible]”JT9D[illegible]·[illegible]Robert Rosati[illegible]0.04[illegible]Y[illegible]80%[illegible]747[illegible]

[illegible]747[illegible]

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[illegible]·[illegible]Thomas Hughes[illegible]

[illegible]

[illegible]

[illegible]747[illegible]

[illegible]JT9D[illegible]JT9D[illegible]

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[illegible]737[illegible]“[illegible]”[illegible]F–35[illegible]

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[illegible]intends something[illegible]“[illegible]”[illegible]mind’s eye[illegible][4][illegible]6[illegible]——[illegible]

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[illegible]C.A.R. Hoare[illegible]1960[illegible][5][illegible]

[illegible]20[illegible]10[illegible]·[illegible]Robert Maillart[illegible][6][illegible]·[illegible]Le Corbusier[illegible]·[illegible]·[illegible]Mies van der Rohe[illegible]

[illegible]

[illegible]·[illegible]David Billington[illegible]1933[illegible]

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· Hyman Rickover [10]

1949

U.S. Atomic Energy Commission

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Mark Hertsgaard “

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1986 101 81

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第6章 技术的起源

新技术可以是根据某个目的或需要发现一个可以实现的原理，也可以从某一新现象出发，找到如何使用这种现象的办法。原理可以借用，也可以是先前概念的组合，或者由理论而来。只有将概念转化为现实，一项新技术才真正诞生。科学和数学中的原创，与技术没什么两样，因为它们同属“目的性系统”。

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[illegible] —— [illegible] originators [illegible] inventor [illegible] “[illegible]” [illegible] · [illegible] · [illegible] · [illegible] – [illegible] —— [illegible] · [illegible] “[illegible]”[3] [illegible] “[illegible] mach-number-sensitive [illegible]” [illegible]

[illegible] “[illegible]” [illegible]

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1928[illegible][4][illegible]

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[illegible]1940[illegible]John Randall[illegible]Henry Boot[illegible][5]

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[illegible]Hertz[illegible]*Electric Waves*[illegible]

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1929[illegible]Ernest Lawrence[illegible]

[illegible]Rolf Wideroe[illegible]

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[illegible] subproblems [illegible]

[illegible] 20 [illegible] 60 [illegible] Xerox [illegible] · [illegible] Gary Starkweather [illegible] “[illegible]” [illegible] 50 [illegible] module [illegible]

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[illegible]tight tolerance[illegible]6[illegible]

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[illegible]“1954[illegible]4[illegible]·[illegible]Jim Gordon[illegible]”[illegible]“[illegible]”[10]

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[illegible]1928[illegible]·[illegible]Alexander Fleming[illegible]“[illegible]·[illegible]John Tyndall[illegible]1876[illegible]·[illegible]Andre Gratia[illegible]20[illegible]20[illegible]“[illegible]”[illegible]

[illegible]effect[illegible]Oxford’s Dunn School of Pathology[illegible]·[illegible]Howard Florey[illegible]·[illegible]Ernst Chain[illegible]13[illegible]——[illegible]

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DNA “ …… ”[14] “ ”

“ DNA DNA”

DNA DNA

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DNA□□□□□□□□□□□□□□□□□□□□□□

·Edwin Layton·

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[illegible]“[illegible]”[illegible]·[illegible]Claude Shannon[illegible]“[illegible]”[illegible]

[illegible]“[illegible]”[illegible]·[illegible]Michael Williams[illegible]

> [illegible]“[illegible]”[illegible] [illegible]ENIAC[illegible]Electronic Numerical Integrator and Calculator[illegible]“[illegible]”[illegible]–[illegible]ABC[illegible]“[illegible]”[illegible]colossus[illegible]Zuse[illegible]Z3[illegible]·[illegible]“[illegible]”[illegible][17]

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[illegible]“[illegible]”[illegible]·[illegible]Andrew Wiles[illegible]

[illegible]subprinciples[illegible]“[illegible]Deligne[illegible]”[illegible]·[illegible]Kenneth Ribet[illegible]“[illegible]Hellegouarch[illegible]——[illegible]”[19][illegible]concatenation[illegible]

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THE NATURE OF TECHNOLOGY

第7章 结构深化

技术一旦走上发展之路，各种各样的版本就会随之出现。通过“内部替换”，开发人员可以用更好的部件（子技术）更换某一形成阻碍的部件。开发人员还可以通过寻找更好的部件或材料，或者加入新组件进行结构深化。旧设计和旧原理一经锁定，就会产生新用途。

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internal replacement

structural deepening

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1 – 4

sub-subsystem

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radial-flow

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1955[illegible]·[illegible]Marvin Frankel[illegible]Lancashire[illegible][7][illegible]“[illegible]”[illegible]

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[illegible]·[illegible]Diane Vaughan[illegible]

> [illegible][8]

[illegible]hysteresis[illegible]

[illegible]adaptive stretch[illegible][9] [illegible]“[illegible]”[illegible]

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THE NATURE OF TECHNOLOGY

第8章

颠覆性改变与重新域定

域并不是若干单体技术的简单相加，它们是连贯的整体，对经济的影响也更大。任何新域，都产生于一个已存在的域——母域，而且参与者开始很少能意识到会发生“颠覆性改变”。但随着理解的深化和实践的固化，新域会慢慢忘记它的母域而横空出世，甚至会极大地提升国家竞争力。

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[illegible]“[illegible]”[illegible]

[illegible]**coherent wholes**[illegible][1][illegible]20[illegible]40[illegible]

[illegible]1829[illegible]19[illegible]30[illegible]adopt[illegible]encounters[illegible]

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[illegible][1][illegible]20[illegible]DNA[illegible]20[illegible]70[illegible]DNA[illegible]DNA[illegible]DNA[illegible]

[illegible]“[illegible]”[illegible]

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[illegible]·[illegible]Stanley Cohen[illegible]·[illegible]Herbert Boyer[illegible]1973[illegible]DNA[illegible]DNA[illegible]DNA[illegible]“[illegible]”[illegible]

DNA[illegible]

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[illegible]·[illegible]Carlota Perez[illegible][3][illegible]

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THE NATURE OF TECHNOLOGY

第9章 进化机制

组合是新技术的潜在来源。组合的威力，在于它的指数级增长。如果新技术会带来更多的新技术，那么一旦元素数目超过一定阈值，可能的组合数就会爆炸性增长。此外，机会利基也在呼唤着新技术。技术就如同生命体一样，它的进化与生物进化也没什么本质差异。

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第10章
技术进化所引发的经济进化

众多的技术集合在一起，创造了一种我们称之为“经济”的东西。经济从它的技术中浮现，不断从它的技术中创造自己，并且决定哪种新技术将会进入其中。每一个以新技术形式体现的解决方案，都会带来新的问题，这些问题又迫切需要进一步得到解决。经济是技术的一种表达，并随这些技术的进化而进化。

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第11章 我们的立场是什么

随着基因组研究和纳米技术的发展，生物正在变成技术。与此同时，从技术进化的角度看，技术也正在变为生物。两者已经开始相互接近并纠缠在一起了。我们需要和自然融为一体。如果技术将我们与自然分离，它带给我们的就是死亡。如果技术加强了我们和自然的联系，那就是它对生命和人性的厚爱。

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1.□□□·□□□Thomas Kuhn□□□□□□□□“□□□□□□”□□□□·□□□□Edward Constant□□□□□□□□□□□□□□□□□“□□”□□

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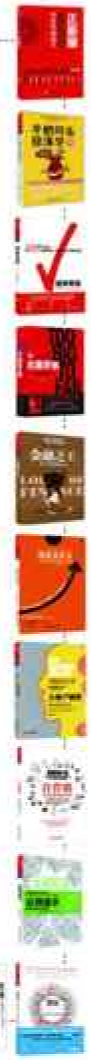
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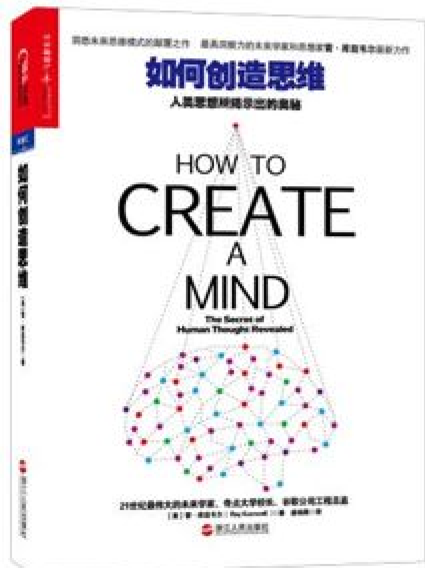
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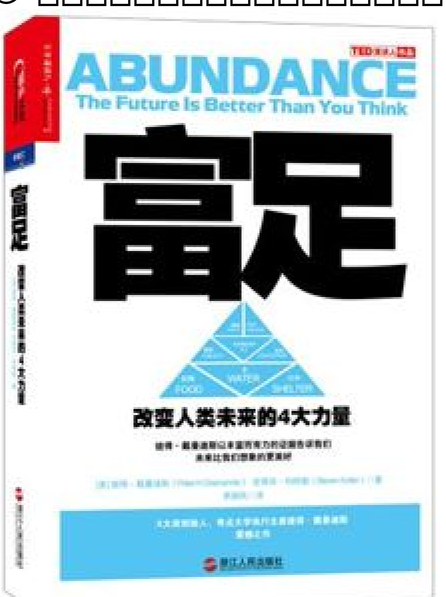


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